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ABSTRACT

A study examined the developmental shifts in the importance of linguistic components of words to single word decoding. Subjects, 1200 children ages 6-7, 8-9, and 10-12.5 years who were the normative sample of the Kaufman Assessment Battery for Children (K-ABC), were tested using a word recognition test, the Reading Decoding Subtest of the K-ABC. Each word was decomposed into nine structural components important to linguistic information: number of phonemes, graphemes, syllables, morphemes, consonant digraphs, vowel digraphs, r-controlled vowels, consonant blends, and silent markers. Results indicated that: (1) for all three age levels, phonemes, graphemes, and syllables were so highly correlated and correlated so similarly to success in decoding that only phonemes were used; (2) for all three age levels, within subject regression coefficients of the seven variables on right-wrong score exhibited the same direction of regression but relative importance varied; and (3) phonemic complexity accounted for the highest amount of variance at each level, with other variables shifting across age in a pattern consistent with a stage development model for reading. Findings suggest questioning the concept of a true automaticity in reading. (One table of data is included; 18 references are attached.) (Author/RS)

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Structural Components of Single Word Decoding

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Abstract

This study examined the developmental shifts in the importance of linguistic components of words to single word decoding. Children at each of three age levels, 6-7, 8-9, and 10-12 1/2 were tested using a word recognition test, the Reading Decoding Subtest of the Kaufman Assessment Battery for Children. Each word was decomposed into nine structural components important to linguistic information: number of phonemes, graphemes, syllables, morphemes, consonant digraphs, vowel digraphs, r-controlled vowels, consonant blends, and silent markers. For all three age levels, phonemes, graphemes, and syllables were so highly correlated and correlated so similarly to success in decoding that only phonemes was used. For all three levels within subject regression coefficients of the seven variables on right-wrong score exhibited the same direction of regression but relative importance varied. Phonemic complexity accounted for the highest amount of variance at each level, with other variables shifting across age in a pattern consistent with a stage development model for reading. The concept of true automaticity in reading is questioned.

Structural Components of Single Word Decoding

Sufficient evidence exists to support the conclusion that skill in recognizing words is strongly related to beginning reading (Adams, 1990; Gough, 1984; Juel, 1991; Stanovich, 1991). The importance of word recognition is further evidenced at advanced levels of reading as well. Word recognition skill is an independent predictor of comprehension for both students in the intermediate grades (Rupley & Willson, in press) and adults (Cunningham, Stanovich, & Wilson, in press). Decoding capabilities account for significant variance in comprehension performance even after measures of intelligence, prior knowledge, and listening comprehension are accounted for.

Although the importance of word recognition as a foundational process of reading is well documented, many of the experimental tasks designed to decompose the decoding process either focus on auditory discrimination of word parts and non-words or segmentation of sound units into a string of phonemes. Lexical aspects are rarely the criterion variable in this body of research. Analyses of syllables, identification of isolated phonemes, manipulation of phonemes, and discrimination of sounds are examples of criterion variables used in such research (Adams, 1990; Gough, 1984).

The intent of the majority of such inquiries is to sort out the role and contribution of phonemic awareness to success in beginning reading and advance the credibility of the major role that word recognition plays in reading. Juel noted, "phonemic awareness is important because it is linked to the ability to decode, which is linked to reading

comprehension" (p. 778; 1991).

Developmental Phases Assumed to Characterize Decoding Skills

A large body of literature on the ability to decode words has conceived it as consisting of a series of phases. Ehri (1991) adopted the terms used by Frith (1985) to describe a three-phase scheme of development in learning to read words. These phases consists of logographic, alphabetic, and orthographic phases. The alphabetic phase is associated with the grapheme-phoneme relationships in reading words. Within the alphabetic phase is phonological recoding, which involves mastery of the system of generalizations for mapping onto phonological forms. Ehri summarized the phonological recoding skills as that which "enables readers to read words by applying grapheme-phoneme correspondence rules" (p. 398, 1991). Readers' movement into the orthographic phase is predicated on the idea that words are analyzed instantly without phonological conversions. Features of this phase are characteristically similar to the concept of "automaticity" proposed by LaBerge and Samuels (1974). Instant analysis of words assumes that capacity-free processing of words occurs during word recognition. Generalizing this to developmental phases of word recognition would suggest that readers' accession of phonemic knowledge should reduce to immeasurably small proportions as they become competent readers. At the least, the amount of word recognition variance explained by phonemic awareness should decrease significantly across levels of reading competence. It may be that knowledge of individual features of phonemes becomes less important as it is internalized or subsumed by larger or more generalizable phonemic units. If this is the case, then it is possible that phonemic

knowledge could be supplanted or subsumed by morphemic knowledge, or as suggested by Adams (1991), predictable strings of phonemic knowledge characteristic of the English language.

Chall (1983) in her developmental stage model of reading suggested that qualitative changes occur in children's reading development as they move from preschool through the grades. Stages 1 and 2 in her model place heavy emphases on the understandings associated with graphemic-phonemic patterns in word recognition. However, in stages three through five phonemic knowledge and utilization is assumed to become automatic. Other stage models (Gibson, 1965; Gough & Hillinger, 1980; Mason, 1980) emphasized the importance of phonemic awareness early in the reading process; once readers have reached the "automatic stage" beginning reading has ended (Juel, 1991), and use of phonemic knowledge in word recognition is characterized as being capacity free.

Although there is sufficient evidence to support stage or phase models of word recognition development and the role that phonemic recoding plays, there may be additional features associated with these stages or phases that go beyond the beginning reading component. That is, phonemic recoding, as suggested by Rupley and Willson (in press) and by Cunningham, Stanovich, and Wilson (in press) contributes significantly to reading performance at higher stages or phases when the criterion variable moves from word recognition to comprehension.

The present study was an attempt to decompose the structural components of single word decoding for developing readers. Additional interests included specifying the contribution that each structural component made to successful word recognition at levels

of reading performance. The structural components were derived from reviews of word recognition and decoding literature (Adams, 1990; Chall, 1983; Stanovich, 1991; Wilson & Hall, 1984). That literature supports potential evaluation of nine different variables: graphemes, phonemes, morphemes, consonant blends, consonant digraphs, silent markers, r-controlled vowels, vowel digraphs, and syllables.

The general theoretical perspective followed in this study was that the presentation of a word for decoding presents to the child a task in which the nine components are invoked in problem solution, or at least are related to the information processing required for solution of the problem. For young children, increases in the complexity of words require greater and greater sophistication in the application of rules for decoding and will be reflected in increases in the quantity of one or more of the variables listed above. Thus, examining variation in these variables in a decoding task can help us to understand the complexity of the decoding task and sort out the relationships between the stimulus and the decoding process.

Method

Subjects

The subjects for this study were 1200 children ages eight to twelve and one-half years. These children were the normative sample of the Kaufman-Assessment Battery for Children (K- ABC). The sample was drawn nationally to mirror the 1980 census with respect to social, gender, and ethnic/racial demographics (Kaufman & Kaufman, 1983).

Instrument

The instrument used was the Reading/Decoding subtest from the Achievement Scale of the K-ABC. This subtest is composed of 38 items: 10 letters and 28 words. For purposes of this study the letter items were omitted and the remaining 28 words were used for the statistical analyses. According to Kaufman and Kaufman (1983), this subtest measures the children's abilities in word attack, word recognition, and pronunciation. Internal consistency reliabilities for this subtest range from .89 to .97 for one year age samples from 6 to 12 1/2 years. Validities are all consistent, with correlations between .50 and .75 with other K-ABC achievement tests, while correlations with various IQ scales are similar in value (.40 to .65).

Children at the 6 - 7 age level attempt items 11 to 31, the 8 - 9 year age group attempts items 17 to 38, and the 10 - 12 1/2 age level attempts items 23 to 38. It is assumed that these older subjects can successfully decode the earlier items unless they incorrectly respond to beginning items, at which point they are evaluated on the earlier items. Only items in the usual testing range were included for these analyses.

Independent Variables

The nine variables noted earlier (graphemes, phonemes, morphemes, consonant blends, consonant digraphs, silent markers, r-controlled vowels, vowel digraphs, and syllables) were employed as independent variables. Each of the 28 words of the Reading Decoding subtest was evaluated for presence and number of occurrences of the nine variables. Each item was broken down into component parts by the researchers and reviewed independently to obtain full agreement.

Dependent Variable

The dependent variable in this study was the right/wrong score on the individual items in the Reading/Decoding subtest.

Analysis

The methodological approach used was general linear model analysis. In order to evaluate the effects of the nine decoding variables, a within subject model was developed. Three age levels were established based both on the range of items attempted and the potential to discover developmental differences. These levels were ages 6-7, ages 8-9, and ages 10-12 1/2.

Between subject variance was removed by subtracting each subject's mean item performance from each item score. Between subject variance was not consider further, although it has been extensively investigated for the K-ABC in other contexts. The residuals of this analysis were regressed on the nine decoding variables. Both forward regression and a full regression model were examined. Also, the correlations among the nine predictors were inspected. These analyses were performed separately for the three reading age levels.

Results

Age level 6-7

Inspections of the intercorrelation matrix of predictors showed that for the words in items 11 to 31, syllables and graphemes (.83), syllables and phonemes (.86), and graphemes and phonemes (.89) were so highly intercorrelated that they were unlikely to yield independent information. Consequently, only phoneme number was included in the final analyses, although preliminary analyses included all nine variables. The

results of the preliminary regressions bore out the high intercorrelations among these three variables, as only one of the three carried the variance for all.

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insert Table 1 about here

The within subjects analysis of seven item components indicated that approximately 22% of the variance was accounted for, with phonemes and morphemes associated with the greatest part (13%) and consonant digraphs and silent markers yielding similar contributions (about 2% each). Type III sums of squares supported relatively independent contributions for these predictors, with phonemes contributing the dominant portion. Increase in phonemes and the presence of consonant digraphs and silent markers were associated with decreased performance, while increasing the number of morphemes from one to two enhanced performance.

Age level 8-9

The intercorrelations among phonemes, graphemes, and syllables were all above .90, thus only phonemes was retained. In the seven predictor within subjects analysis, of the 41% of total sums of squares accounted for, phonemes contributed the greatest proportion (17%). Consonant blends (8%) and r-controlled vowels (9%) were the other consistent and large predictors, although morphemes (5%) and consonant digraphs (3%) were both significant and independent predictors.

Increases in the number of phonemes and consonant digraphs were associated with decreased item performance. Increases in morphemes, consonant blends, and r-

controlled vowels were associated with enhanced performance.

Age level 10-12 1/2

As with age levels 6-7 and 8-9, syllables, graphemes, and phonemes were so highly correlated that only phonemes were considered in the final analysis.

The initial general linear model with all seven predictors accounted for 26% of the within subject variance. Phonemes accounted for approximately 11%, r-controlled vowels 7%, consonant blends 3%, and consonant digraphs and silent markers about 2% each. These variables' contributions held up under Type III sums of squares analysis.

Again, increasing the number of phonemes led to decreased performance, as did increasing the number of consonant digraphs and silent markers. Increasing the number of consonant blends and r-controlled vowels enhanced performance.

Discussion

It should be no surprise that a construct based on word length such as phoneme number is negatively correlated with the probability of correctly decoding the word. Also, at each age level it is theoretically supportable that phoneme number is the variable most highly related with probability of correct solution among the set of variables studied.

The intercorrelation of syllables, phonemes, and graphemes suggests that these features do not function independently in decoding isolated words. Graphemes and syllables reflect a construct based on the visual components of the stimulus words that symbolize phonemes. Both of these features have been suggested to be essential

because they parallel the spoken language, where only certain sequences of sounds are permissible (Adams, 1990). The interrelationship between graphemes, syllables, and phonemes in decoding is further supported by the work of Mewhort and Campbell (1981), who found that readers process words into syllables while reading and that there is a reinforcement of memory association of letters within syllabic patterns. This reinforcement is what facilitates the phonemic representation for word recognition. The fact that at each of the three reading levels, phonemes accounted for the greatest amount of significant variance indicates that it played a major role in word recognition.

Attention to the significant contribution that other structural features made in the decoding of words at the three reading levels is warranted. At age level 6-7, an increase in consonant digraphs and silent markers was associated with decreased performance. At age level 8-9, increases in morphemes, consonant blends, and r-controlled vowels were associated with enhanced performance. Finally, at age level 10-12 1/2, an increase in consonant blends and r-controlled vowels was associated with enhanced performance. Children at all three levels showed the same pattern of effect of the seven structural features on performance. What changed across age was the relative importance of the variables.

Phonemes. Phonemes contributed significantly across all three age levels to performance. One might anticipate a decrease in phoneme importance across the three age levels because as children move to the next higher age level they should be acquiring greater facility in using phonemic information in decoding words (LaBerg & Samuels, 1974). The idea of automaticity suggests that children at higher age levels

would be more familiar with letter patterns and combinations than children at lower age levels, thus relying less on individual phonemic features in words to decode them. Furthermore, stage theories of reading propose that phonemic capabilities are generally well developed by ages 10 - 12 1/2 and that strings of letters representing sounds are well internalized as a means of facilitating word recognition.

Phonemes were associated with the greatest amount of variance for age level 8-9. Children in this age range are typically in third or fourth grade. Adams (1990) noted readers at fourth grade exhibit the adult ability to perceive syllables as units within words and nonwords more quickly and accurately than single letters. Since grades three and four are clearly a transitional stage in reading development (Adams, 1990; Chall, 1983; Stanovich, 1991), increased variance due to phonemic complexity could be explained by decoding capabilities differences between good and poor readers. It is at this age level that good readers begin to "chunk" words into syllables as one of the primary means of decoding.

The reduction of variance associated with phonemes at age level 10-12 1/2 could by explained by differentiation between good and poor readers with relative homogeneity within the groups. That is, good readers are fairly similar in their decoding capability by this age, and poor readers have not progressed beyond the individual letter level in word recognition.

Consonant blends and r-controlled vowels

Both consonant blends and r-controlled vowels exhibited the same pattern of association in decoding words. At the earliest age level they did not contribute to

children's successful decoding, while at the older age levels their presence enhanced children's ability to identify words. We interpret this to suggest that children in the 6-7 age group were still focusing on individual letters as the primary carriers of decoding information. Children in the two older groups appear able to use information about letter combination information in their successful decoding. This finding provides support for the developmental concept associated with word recognition. Children become more capable in discerning and utilizing letter strings and letter combinations as a result of knowledge about alphabetic principles, which include predictability of consonant succession and vowel sounds (Adams, 1990).

Conclusions

The results presented here advance the credibility of a stage model of reading decoding development. Some elements of stage models, however, can not be supported. Automaticity or capacity free decoding can not be assumed to increase independent of phonemic structure. Children's and adults' word recognition capabilities are fundamentally limited by letter and letter combination characteristics.

The results further contradict whole language proponents' assumptions that readers process text in word and phrase units without attention given to significant phonemic and structural word features. Clearly the findings support the conclusions reached by Stahl and Miller (1989) and Adams (1990) for beginning and intermediate readers that phonemic information is critical to successful word decoding, and that even for proficient readers such information remains important in recognizing words.

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Table 1: Sums of Squares for Single Word Decoding Due to Structural Components at Three Age Levels

Ages 6-7

Within Subject	Type I SS[1]	Type III SS[1]	Regression coefficient[2]
PHONEMES	161.8	215.4	-.15
MORPHEMES	18.9	72.1	.42
CONSONANT BLENDS	12.5	14.2	.11
DIGRAPH CONSONANTS	25.4	41.9	-.21
SILENT MARKERS	32.5	39.0	-.22
R-CONTROLLED VOWELS	5.9	6.3	.07
DIGRAPH CONSONANTS	8.1	8.1	-.16
ERROR (DF=8392)	963.2		

$R^2 = .22$

Ages 8-9

Within Subject	Type I SS[1]	Type III SS[1]	Regression coefficient[2]
PHONEMES	281.9	472.3	-.14
MORPHEMES	86.2	52.3	.27
CONSONANT BLENDS	139.0	187.8	.37
CONSONANT DIGRAPHSS	50.5	47.9	-.19
SILENT MARKERS	20.3	6.0	-.05
R-CONTROLLED VOWELS	167.2	171.4	.34
VOWEL DIGRAPHS	4.2	4.2	-.08
ERROR (DF=8792)	1812.2		

$R^2 = .41$

Ages 10-12 1/2

Within Subject	Type I SS[1]	Type III SS[1]	Regression coefficient[2]
PHONEMES	162.0	148.9	-.11
MORPHEMES	0.0 (ns)	11.6	.19
CONSONANT BLENDS	53.0	87.1	.36
CONSONANT DIGRAPHS	34.9	20.4	-.12
SILENT MARKERS	36.1	20.4 (ns)	-.01 (ns)
R-CONTROLLED VOWELS	99.0	102.1	.33
VOWEL DIGRAPHS	4.8	4.8	-.13
ERROR (DF=7976)	1492.1		

$R^2 = .26$

[1]All mean squares associated with sums of squares were significant at $p < .001$ except those marked (ns).

[2]All regression coefficients except those marked (ns) were significant at $p < .001$.